Rotational Equilibrium

Name: _____ Section: 2AL-___ Date performed: __/__/__

Lab station: _____ Partners: _____

A. Conditions for equilibrium

(Q-1) Determine the location of the center of gravity of the meter stick by balancing the meter stick alone.

$$x_{\text{cg}} = (\_\_\_\_\_ \pm \_\_\_\_\_)\,\text{cm}$$

(Q-2) Now balance the meter stick with 3 weights attached. Use three different weights, each between 100 gwt and 500 gwt.

	position (cm)	weight (gwt)	lever arm (cm)	torque (gwt cm)
1	±	±	±	±
2	±	±	±	±
3	±	±	±	±

Sum of clockwise torques = _____ ± _____

Sum of counterclockwise torques = _____ ± _____

Use this space for calculations.

(Q-3) Do the torques balance? Use the discrepancy test and explain your results.

B. Weighing a rock

(Q-4) Balance the meter stick with two weights and a rock.

	position (cm)	weight (gwt)	lever arm (cm)	torque (gwt cm)
Rock		XXXXXX		XXXXXXXX
Weight 1				
Weight 2				

(Q-5) Assume that the torques balance and use this fact to calculate the weight of the rock.

$$W_{\text{calc}} = \_\_\_\_\_$$

(Q-6) Measure the weight of the rock using an electronic balance.

$$W_{\text{meas}} = \_\_\_\_\_$$

Calculate the percent discrepancy.

$$\%\ \text{discrepancy} = \frac{|W_{\text{meas}} - W_{\text{calc}}|}{W_{\text{meas}}} \times 100\% = \_\_\_\_\_$$

Up to this point, we have not considered the weight of the meter stick or the upward force acting on the meter stick due to the fulcrum. Why can we get away with this?

C. Weighing the meter stick itself

(Q-7,8) Move the fulcrum away from the center of gravity (not by too much or too little — by about 20 cm is good), and balance the system with one weight.

New fulcrum position = _____

	position (cm)	weight (gwt)	lever arm (cm)	torque (gwt cm)
Meter stick		XXXXXX		XXXXXXXX
Weight				

(Q-9) Calculate the weight of the meter stick.

$$W_{\text{calc}} = \_\_\_\_\_$$

(Q-10) Measure the weight of the meter stick by itself, as well as the clamp by itself.

$$W_{\text{meter-stick}} = \_\_\_\_\_ \qquad W_{\text{clamp}} = \_\_\_\_\_$$

Compare the calculated weight in (Q-9) to the measured weight of the meter stick, either with the clamp or without. You must decide if the clamp's weight should be included or not, and back your decision with physical reasoning ("because it's closer" is *not* a valid reason).

$$W_{\text{meas}} = \_\_\_\_\_$$

$$\%\ \text{discrepancy} = \frac{|W_{\text{meas}} - W_{\text{calc}}|}{W_{\text{meas}}} \times 100\% = \_\_\_\_\_$$

Exercises

Throughout this lab, we have used extensively the second condition of static equilibrium, namely that the sum of the torques must be zero. However, the first condition, namely that the sum of the forces themselves must also be zero, must also hold for static equilibrium to exist. Using this fact along with your data from Part C, determine the force (magnitude and direction) exerted on the system by the fulcrum support in Part C of the experiment.

Did the weight of the clamp figure into your calculations? How is this different from (Q-9) and (Q-10)?